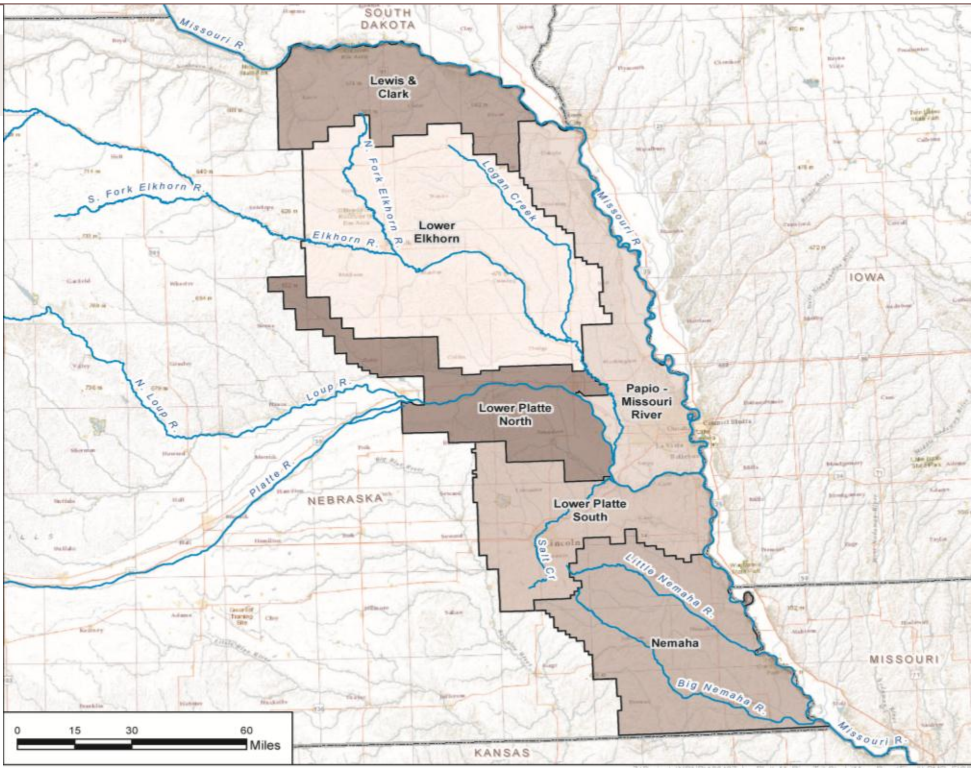
Hydrogeologic Assessment for Potential Development of Groundwater Modeling Tools in the Lower Platte River and Missouri River Tributary Basins

January 28, 2013



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HDR Engineering, Inc.

Meeting Agenda

- Review of project scope and study objectives
- Purpose of Potential Groundwater (GW) Tools
- Summary of Data and Studies Identified
- Presentation of Recommended Future Steps

Background

- Per LB 962, the NDNR is tasked with conducting an annual evaluation of all basins not currently designated as fully appropriated or over appropriated
- A new methodology is currently being developed to evaluate basins' status as fully appropriated
  - The new methodology involves estimating the Basin Water Supply and then assessing the Basin Water Supply relative to current water demands.
- The NDNR must also utilize the best scientific data and information available to conduct the evaluations.
  - New methodology requires use of historic groundwater depletions
  - NDNR is working to develop GW tools, where feasible, and in areas not currently represented by GW Models

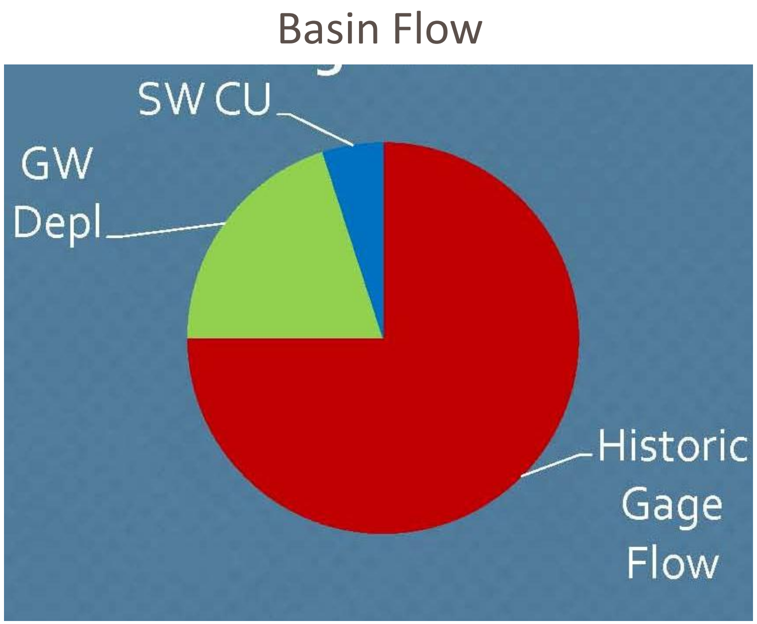
Purpose of a Potential Groundwater Tool

- Basin Flow Hydrograph

  Estimate of streamflow hydrograph without “activities of man”
- Historic gaged flows + upstream consumptive uses:
  – *Basin Flow = Historic flow*

  + historic SW CU

  + estimated GW depletions
- **GW Tool/Methods used to calculate GW depletion factor**
  – **Transient Mass Balance Calculator**



Study Objective

- Assess the available data that could be used to develop GW tools to support NDNR's Annual Evaluations.
- Provide an outline of a suggested GW tool development approach that could be used to support NDNR’s Annual Evaluations using the New Methodology.

HDR Project Scope

- Assess Available Data and Tools
  - Contact ENWRA and NRD Staff to discuss groundwater projects within the study area
  - Review UNLCSD and USGS databases
  - Review existing groundwater models
- Synthesize data into a conceptual model
  - Including electronic datasets and databases
- Develop an outline of a suggested GW tool development approach

NRD Contacts and Data/Studies Evaluated

First Step –Assess Available Data and Tools

- Find Data
  - Met with Dana Divine – UNL-CSD (ENWRA)
  - Reviewed State/USGS databases
  - Contact NRD's

NRD Staff Contacted

- ***Lewis and Clark NRD – Tom Moser***
- ***Lower Elkhorn NRD – Rick Wozniak***
- ***Lower Platte North NRD – Larry Angle***
- ***Lower Platte South NRD – Dick Ehrman***
- ***Papio-Missouri NRD – Brian L. Henkel***
- ***Nemaha NRD – Chuck Wingert***

State/USGS Data Identified/Evaluated

State Data

- Statewide Test-hole Database (UNL-CSD)
- Groundwater-Level Changes (UNL-CSD)
- Statewide Groundwater Level Program (UNL-CSD)
- Registered Groundwater Wells (NDNR)

USGS Data

- National Water Information System (NWIS)
  - Groundwater
  - Surface water

Model Studies Reviewed

- Lower Salt Creek Aquifer Ground Water Modeling Project
- Nemaha NRD Ground Water Modeling Study
- USACE Former Nebraska Ordnance Plant Groundwater Modeling Studies
- Optimizing Management of Surface Water and Groundwater in the Platte River Valley, Eastern Nebraska, using the Farm Process for MODFLOW
- Elkhorn-Loup Model. Simulation of Ground-Water Flow and Effects of Ground-Water Irrigation on Base Flow in the Elkhorn and Loup River Basins (USGS, 2010)

NRD Data not in other DNR/USGS Databases

- ***Lewis and Clark NRD –***
  - Hydrogeologic and Aquifer Delineation Study
  - Two continuous groundwater level recorders
- ***Lower Elkhorn NRD***
  - Aquifer test performed at Oakland
  - Some transducer water level data not reported to USGS/CSD
- ***Lower Platte North NRD***
  - Subarea Delineation Study
  - Limited low flow streamflow data
  - Aquifer tests/stream sampling. Documents are in review/publication.
  - Platte Valley groundwater model. Document is under review.
- ***Lower Platte South NRD***
  - Aquifer test performed at Hickman
  - Supplemental water level data that is not supplied to USGS/CSD
  - Salt Creek Groundwater Model
- ***Papio-Missouri NRD – Brian L. Henkel***
  - Farm process model. Report is not complete.
  - USGS Aquifer Study – Published 2012
- ***Nemaha NRD – Chuck Wingert***
  - Groundwater Database Development and Resource Evaluation Report (includes model)
  - Two aquifer pumping tests Talmage/Brock area.
  - Groundwater Model of Talmage/Brock and Cook areas
  - Transmissivity map generated by the UNLCSD

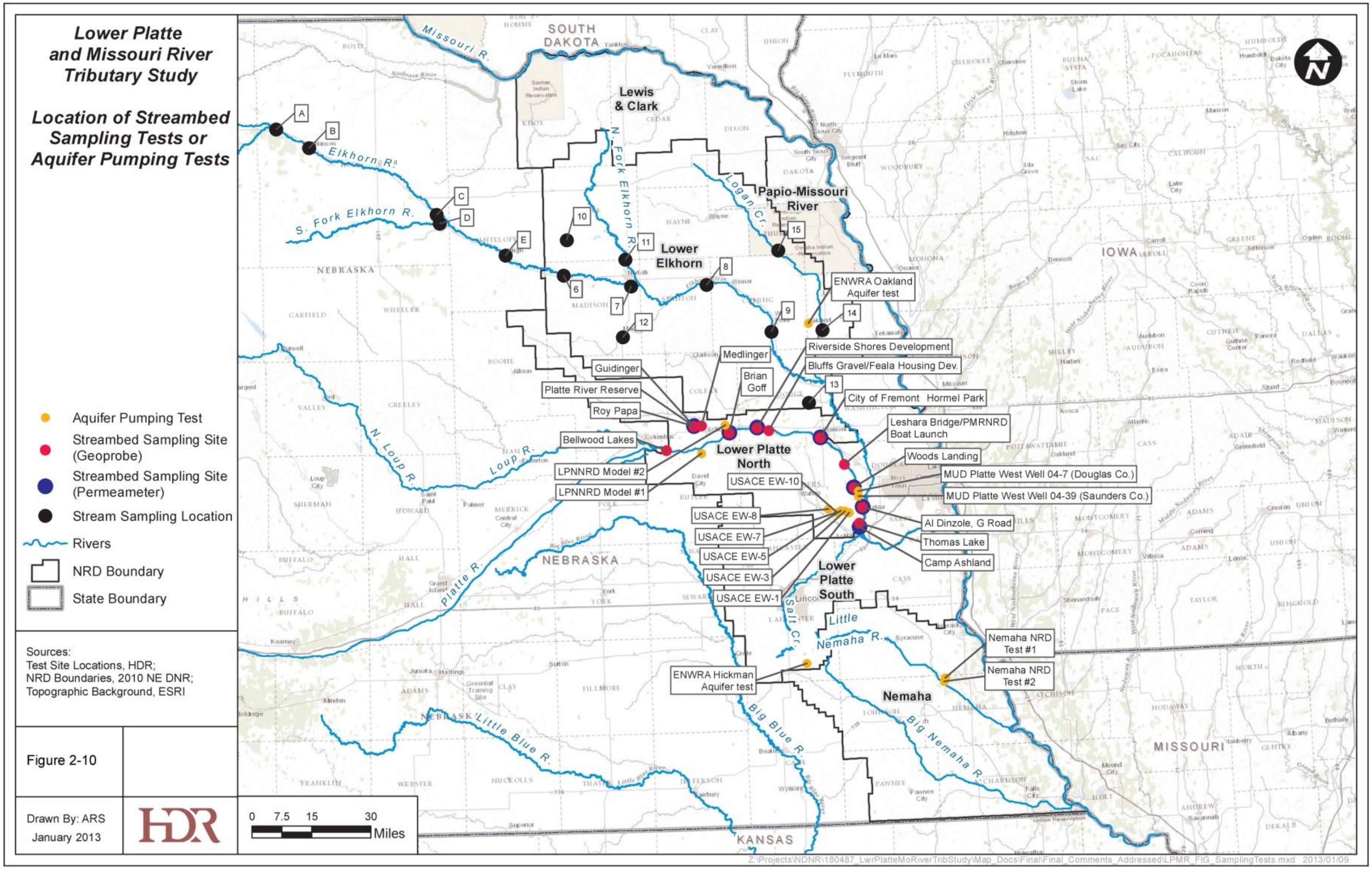
ENWRA Studies

- Evaluation of Geophysical Techniques for the Detection of Paleochannels in the Oakland Area of Eastern Nebraska as Part of the Eastern Nebraska Water Resource Assessment

- Three-dimensional hydrostratigraphy of the Firth, Nebraska Area: Results from Helicopter Electromagnetic (HEM) mapping in the Eastern Nebraska Water Resources Assessment

- Three-dimensional hydrostratigraphy of the Sprague, Nebraska Area: Results from Helicopter Electromagnetic (HEM) mapping in the Eastern Nebraska Water Resources Assessment 2009b

Aquifer Tests and Streambed Conductance



Processed Data from State Databases for Potential Use in Modeling Study

Processed Databases

Databases used to Develop HDR Interpretation of:

- Groundwater Levels (2010)
- Regional Transmissivity
- Saturated Thickness

Summarized and Evaluated Others Interpretation of

- Change in Groundwater Elevations Since Predevelopment
- Base of Principal Aquifer
- Aquifer Tests/Streambed Samples
- Bedrock
- Recharge

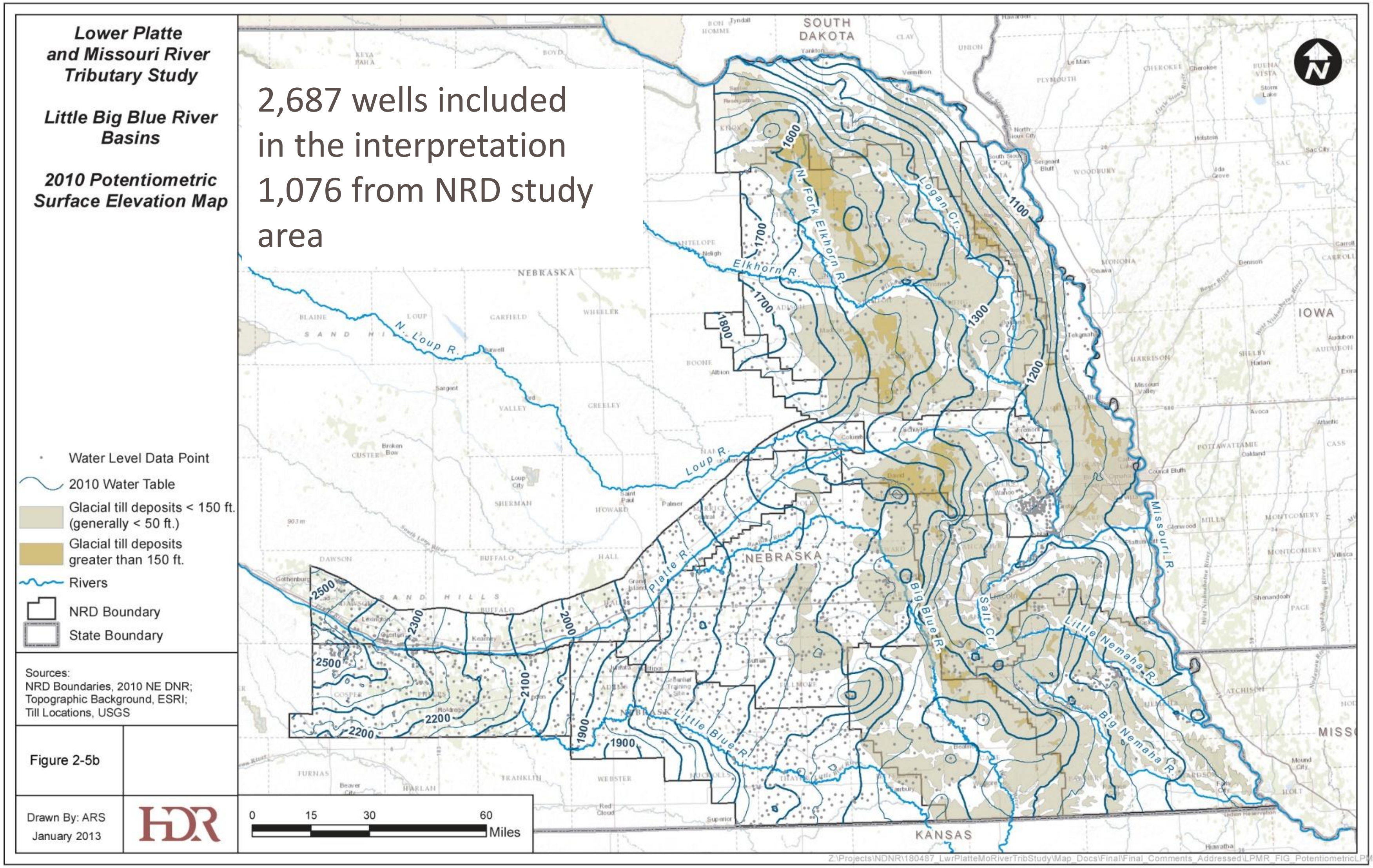
Groundwater Elevation Data

- Primary Data Sources
  - UNL-CSD Statewide Water Level database
  - UNL-CSD Water Level Change maps
  - 10-meter DEM

- Methodology
  - Evaluate available spatial and temporal distribution
  - Calculate surface elevation from DEM and water level elevations from depth-to-water data
  - Generate hydrographs, or interpolated grids and contour maps
  - QC and editing by hydrologist

2010 Water Table Map

2,687 wells included in the interpretation
1,076 from NRD study area



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Hydrogeologic Properties

- Properties
  - Saturated Thickness
  - Hydraulic Conductivity
  - Transmissivity
  - Specific Yield/Storativity (no results to date)
- Data Sources
  - UNL-CSD Test Hole database
  - GeoParam

Hydrogeologic Properties (continued)

- Test hole database includes layer intervals (thicknesses) and lithologic descriptions
- GeoPARAM assigns hydraulic conductivity (**K_i**) and specific yield (**S_i**) values based on the lithologic description for each layer
- Layer saturated thickness (**m_i**) calculated by assigning elevations to each layer and comparing to 2010 water table elevation

Hydrogeologic Properties (continued)

- Layer transmissivity (**T_i**) $T_i = K_i * m_i$
- Borehole transmissivity (**T**) $T = \Sigma T_i$
- Borehole Saturated Thickness (**m**) $m = \Sigma m_i$
- Borehole Effective Hydraulic Conductivity (K_{eff}) $K_{eff} = T / m$

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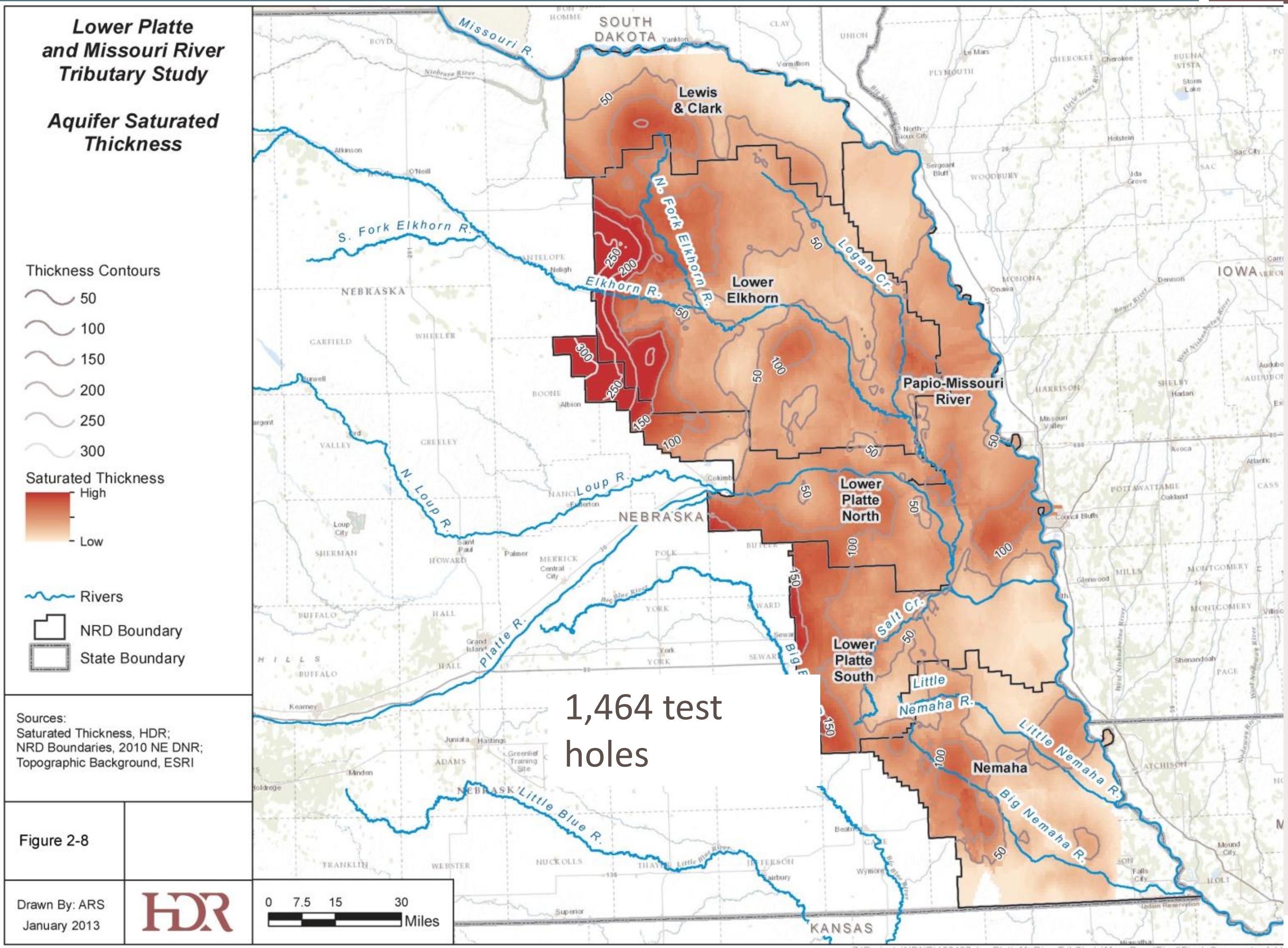
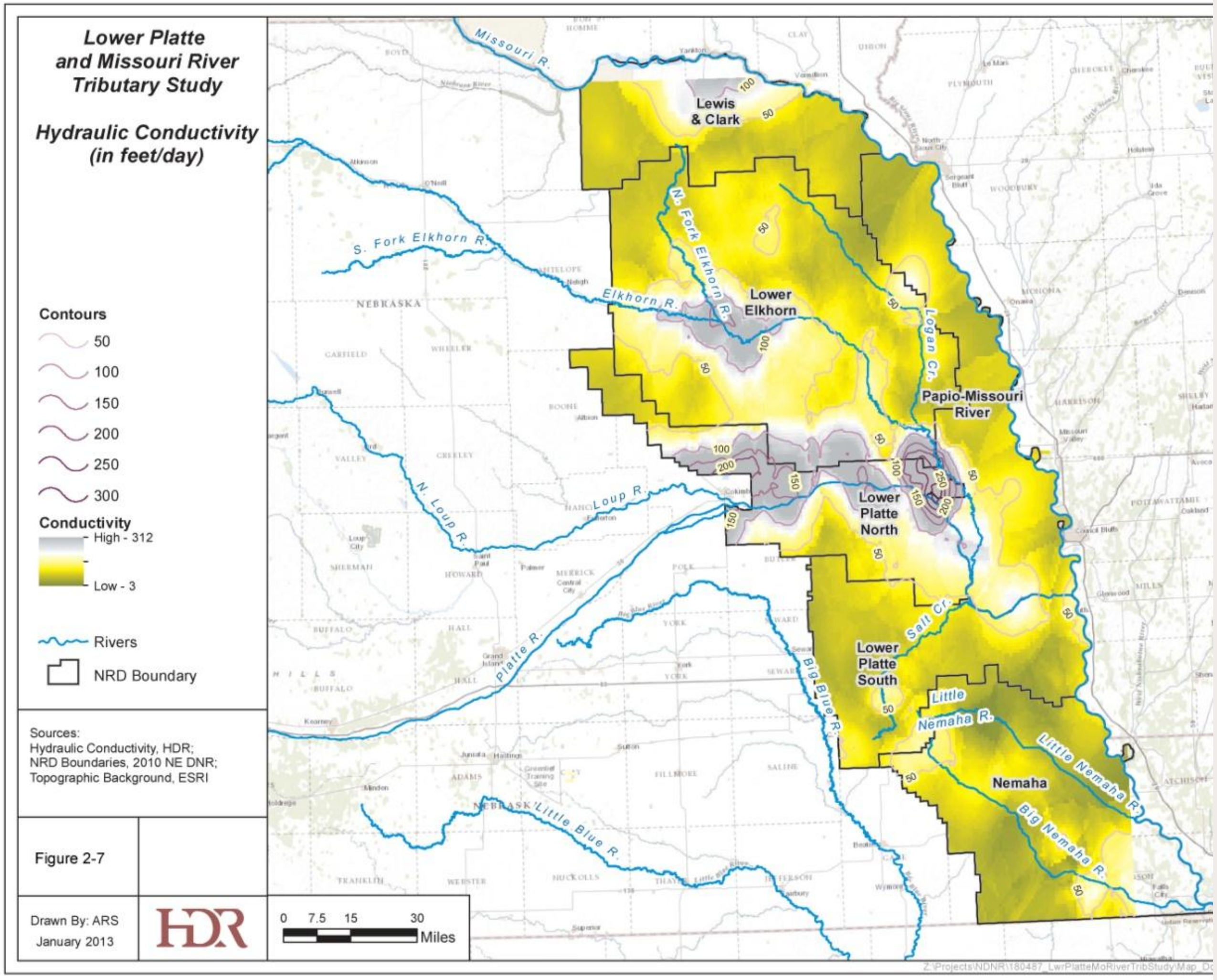
Saturated Thickness (Calculated by HDR)



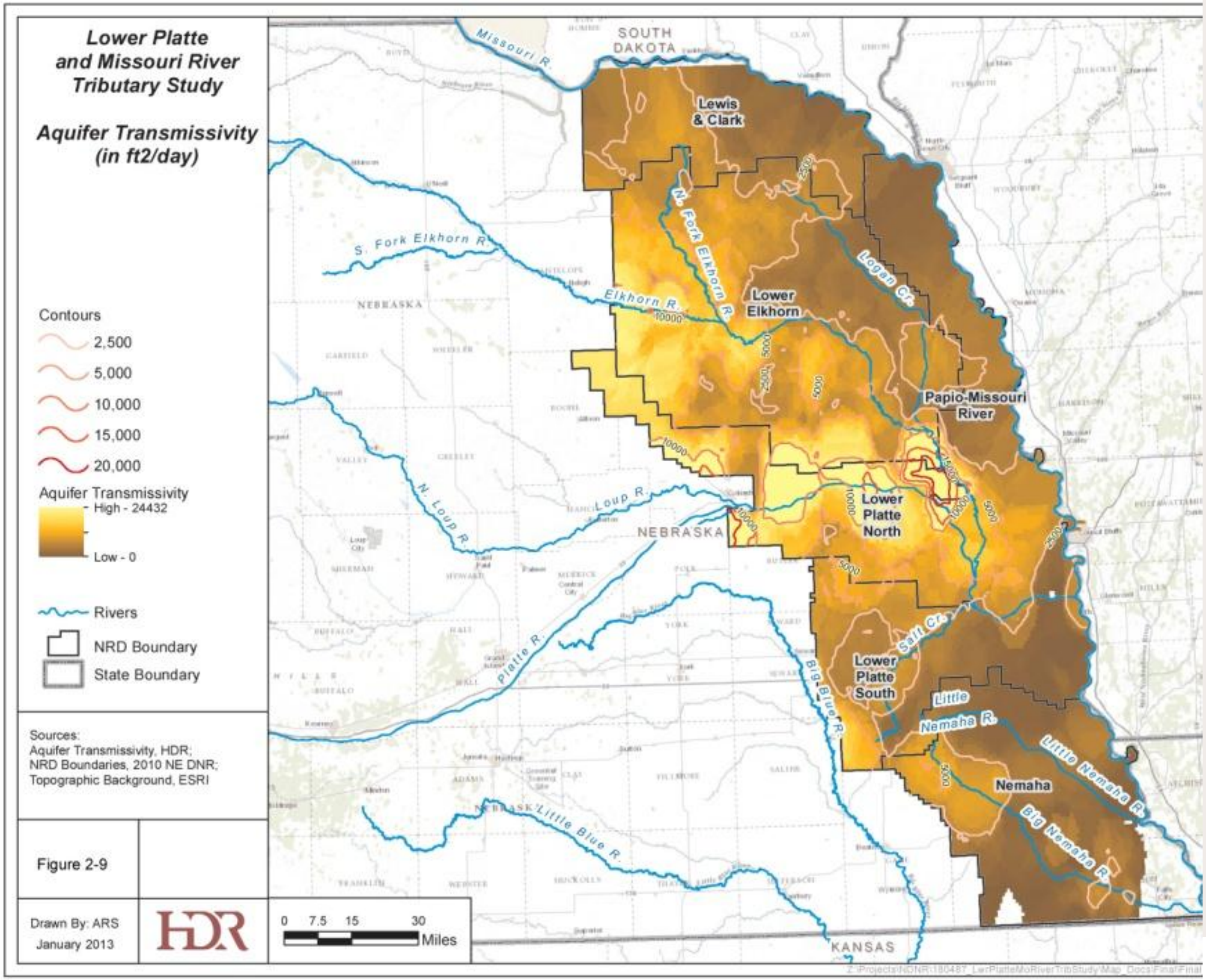
1,464 test holes

Hydraulic Conductivity (Calculated by HDR)

Over 1,400 logs included in the interpretation of K and T



Transmissivity (Calculated by HDR)



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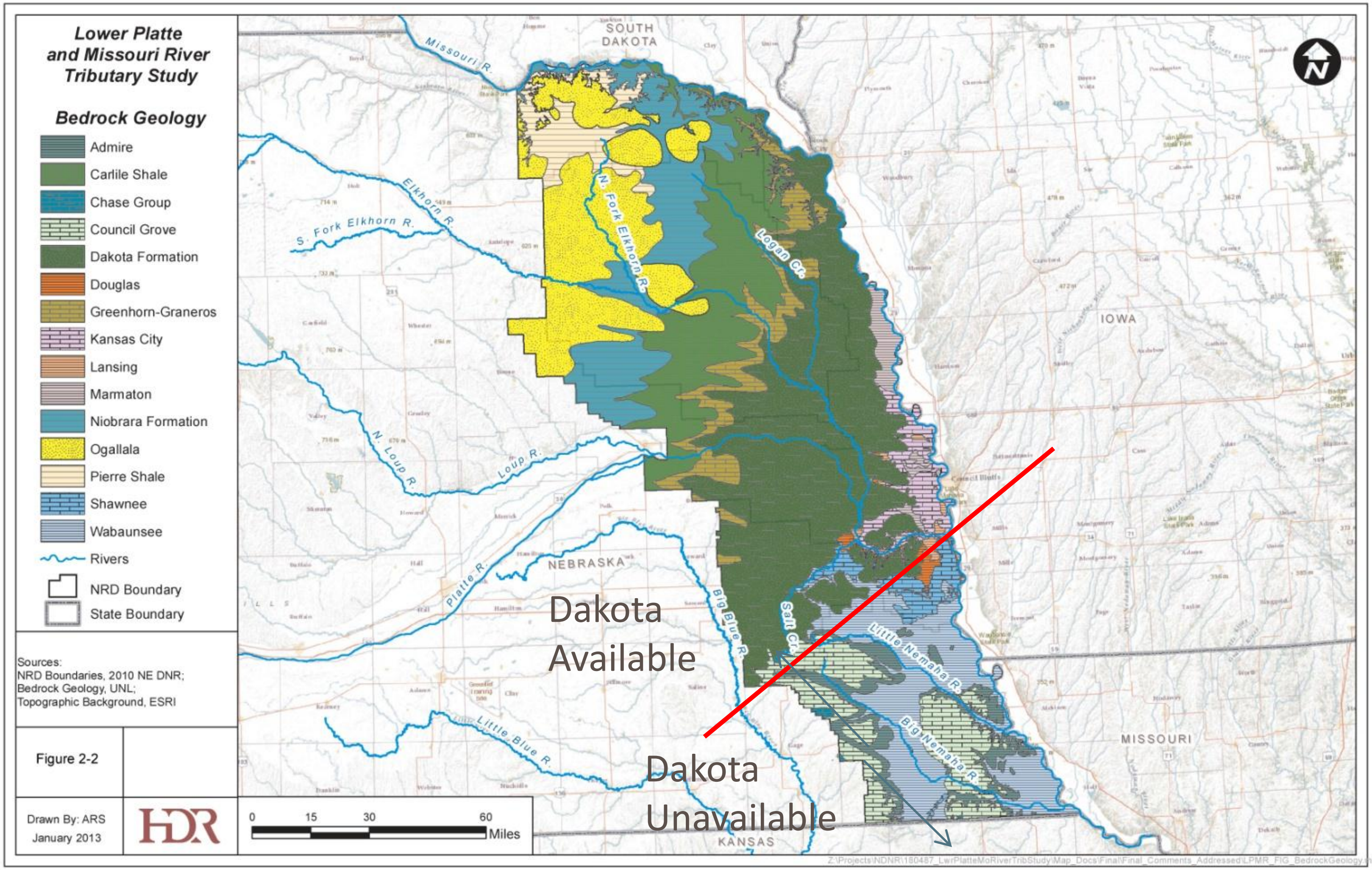
Existing/Unmodified Data

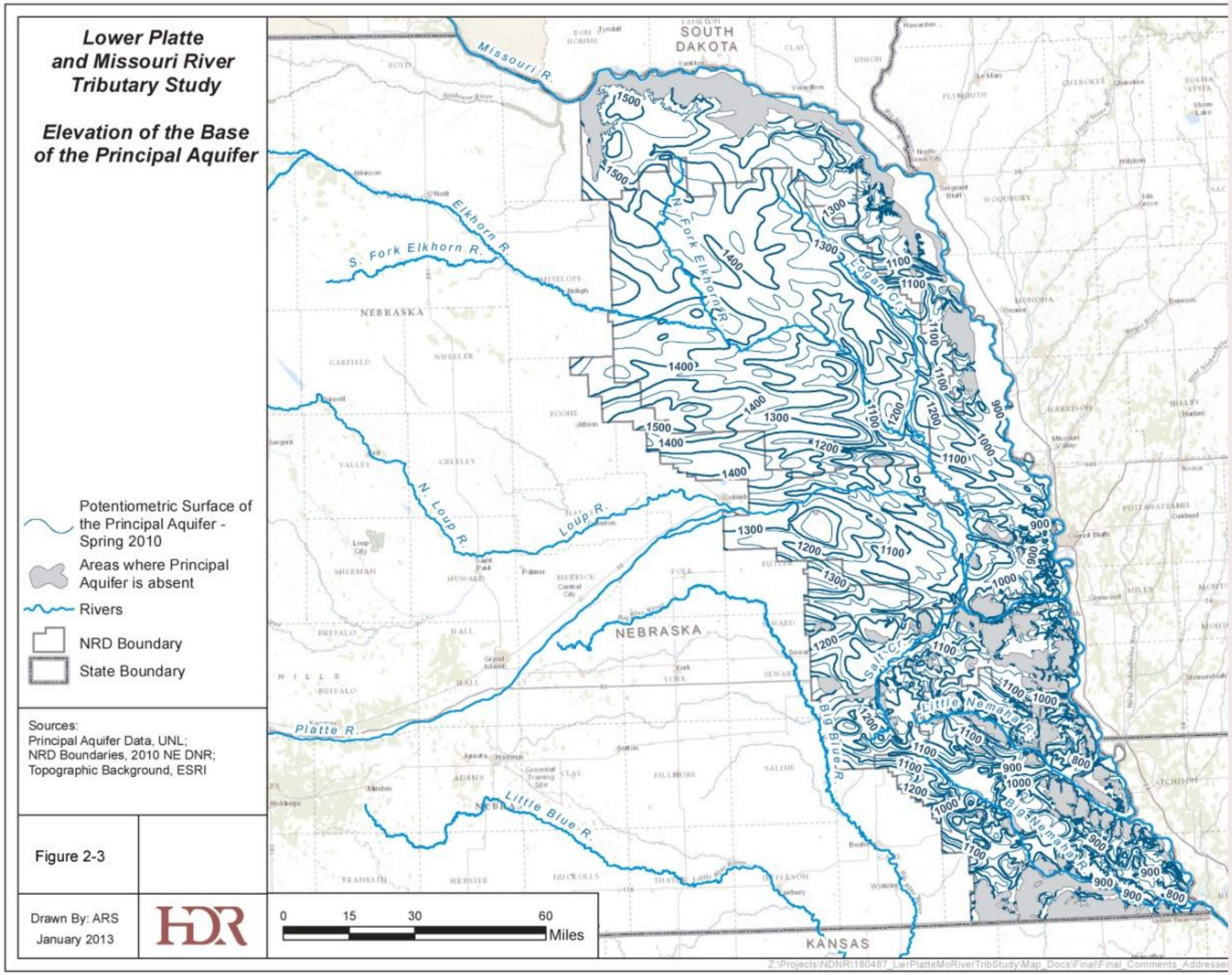
First Bedrock Unit



Base of Principal Aquifer (or Top of Bedrock)

- Base of Principal Aquifer
Is defined and mapped

- Cross referencing with test hole data

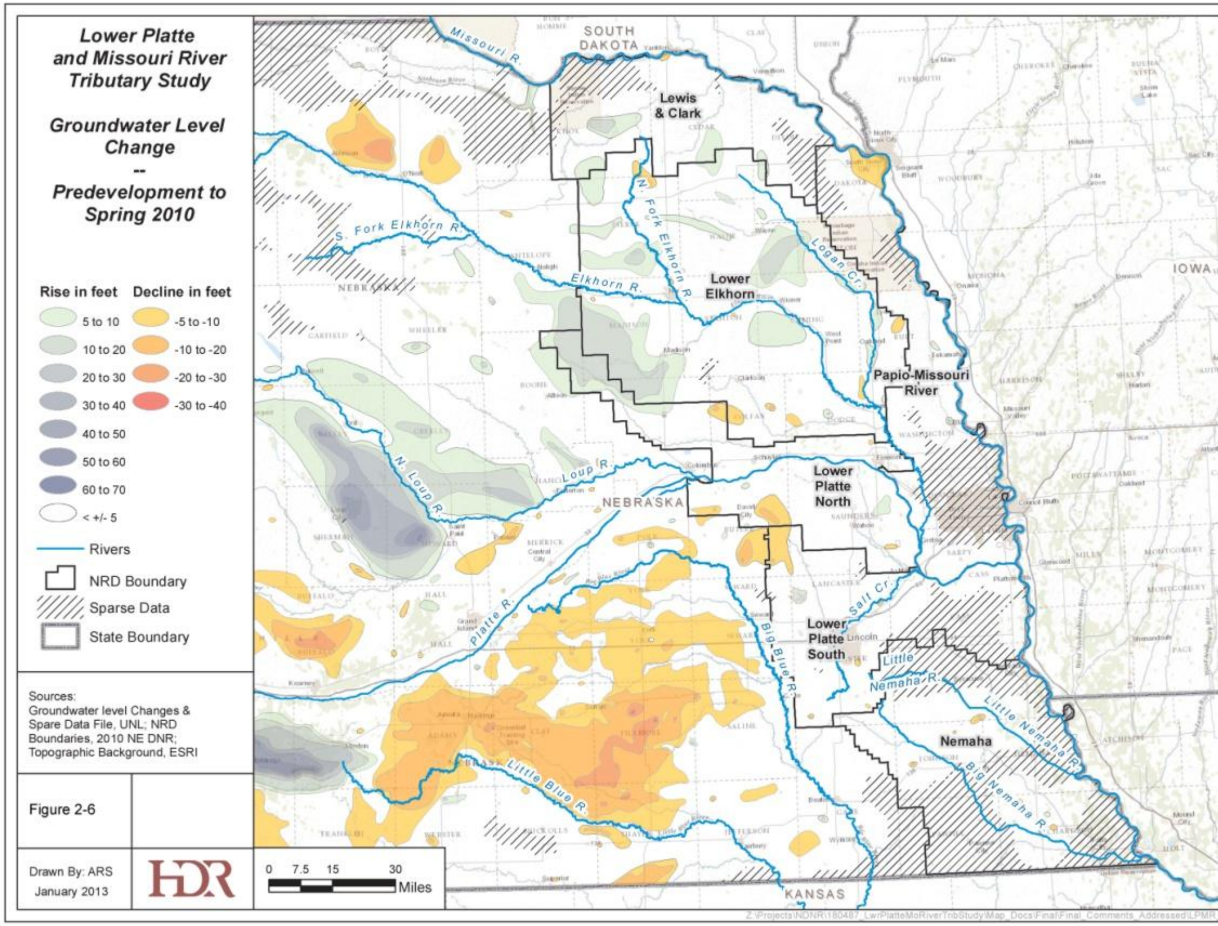


Top of Dakota Aquifer System

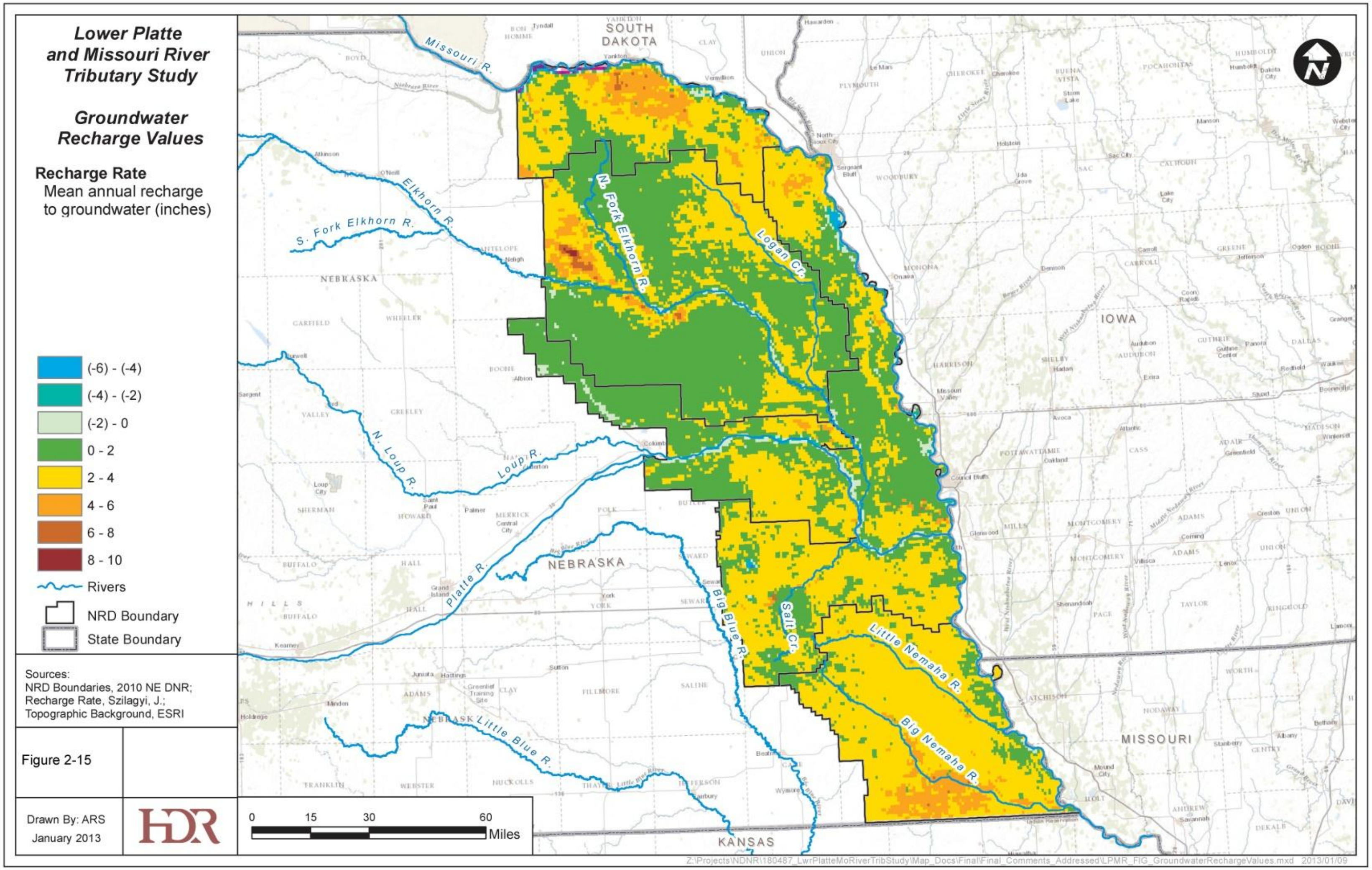
- USGS Open-File Report (OFR) 86-526, *Hydrogeologic Data For The Dakota Aquifer System In Nebraska* (Ellis, 1984).
  - Over 1,900 well logs were evaluated in this document, and for each of these well logs, the
  - USGS determined the top and bottom of the Dakota Aquifer. Approximately 35 of the well logs are within the boundaries of the Study Area.
    - Data supplemented with borings from UNL-CSD Study of the Dakota in Lancaster County

Water Level Change Maps - 2010

- No large declines, some rise
- Similar to 1979

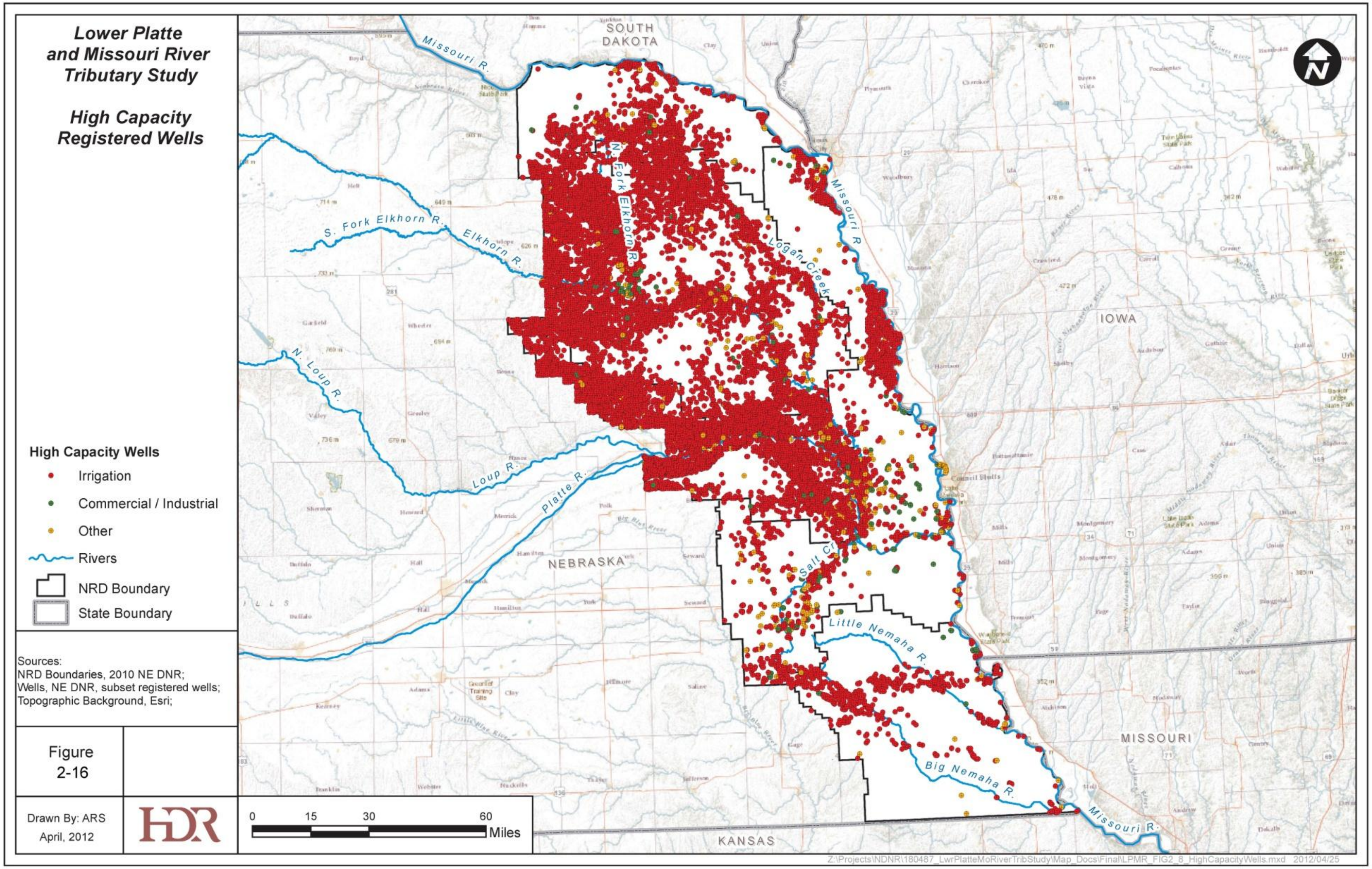


Annual Net Groundwater Recharge

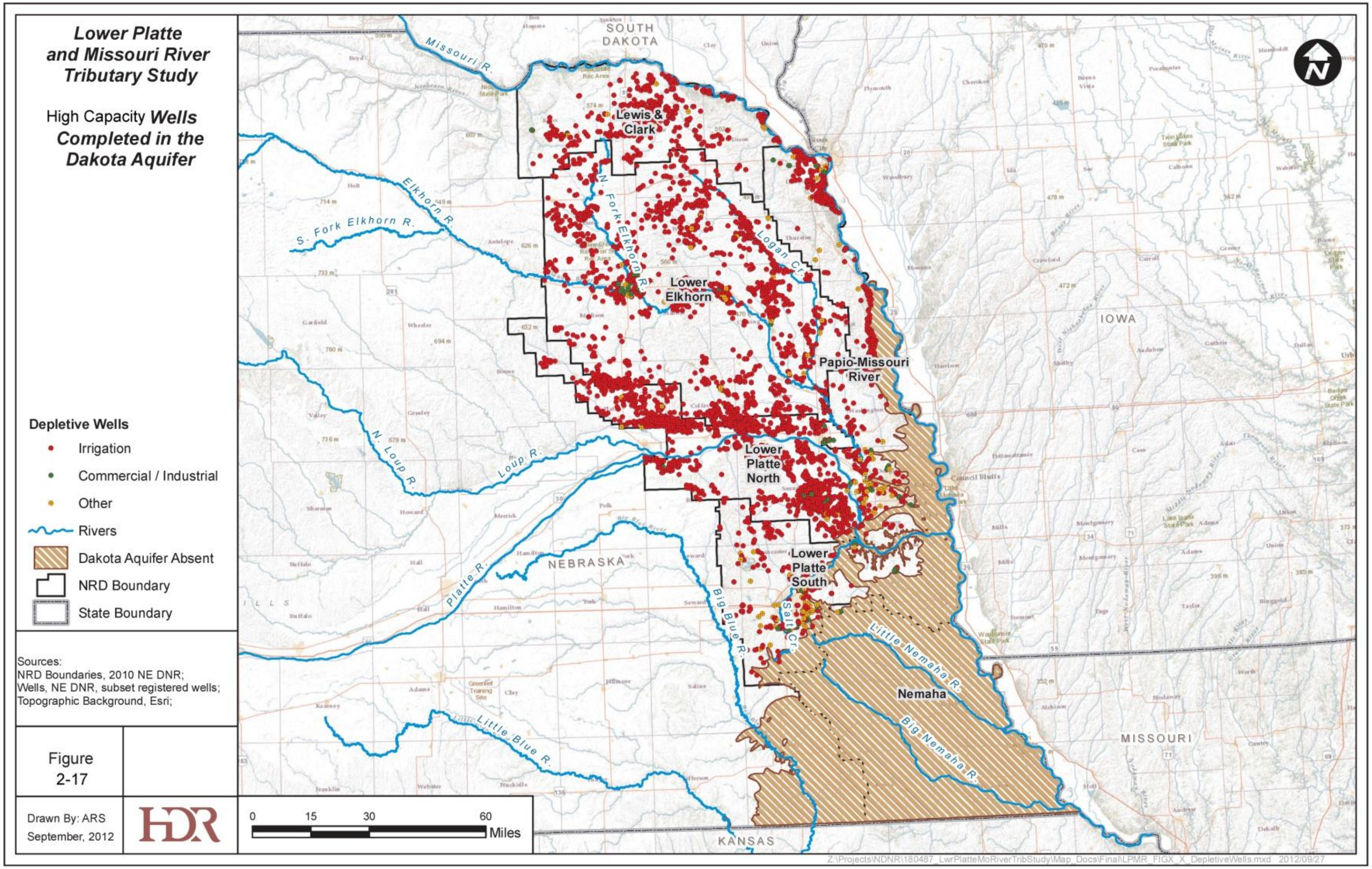


Szilagy, et. al. 2012

Registered High Capacity Wells in the Principal Aquifer

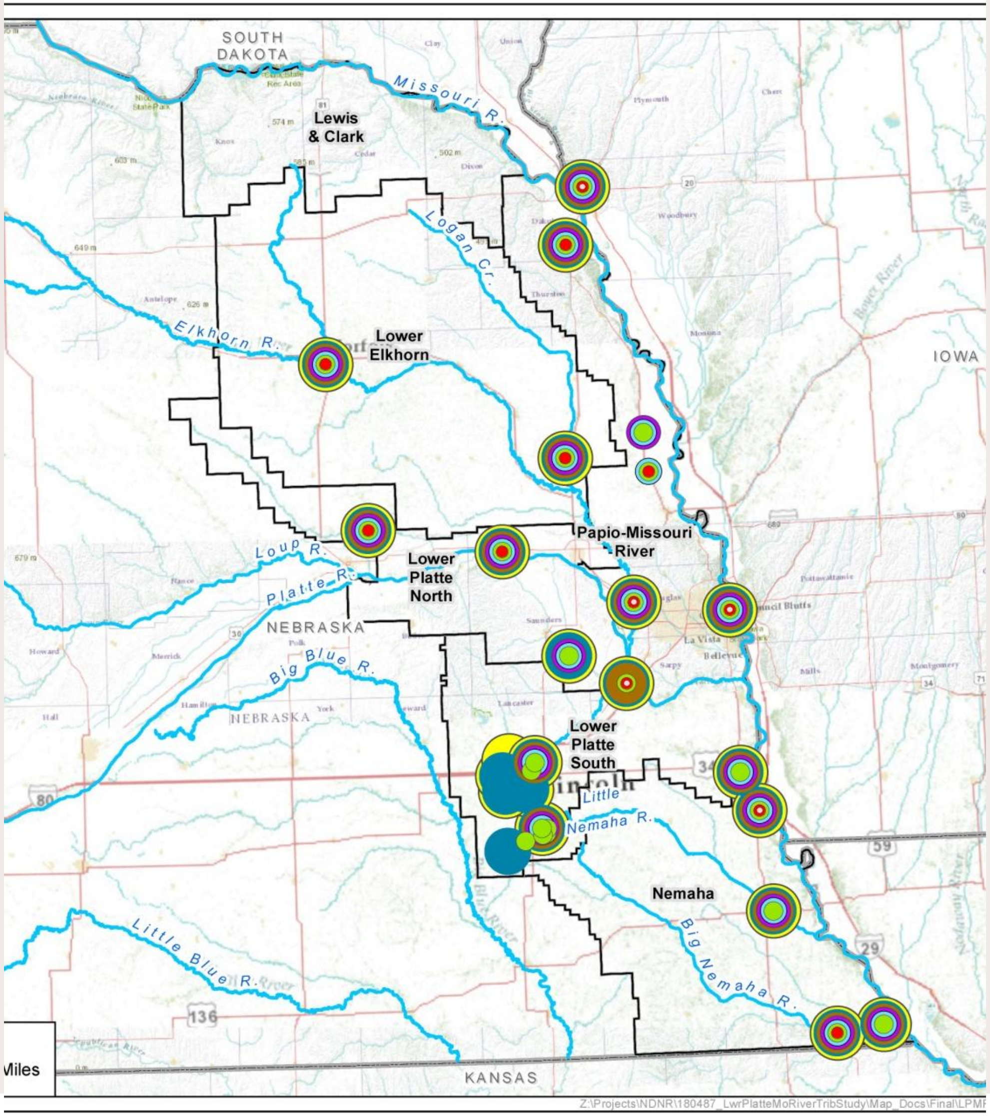


Registered High Capacity Wells in the Dakota Aquifer



USGS Gauging Stations – Extended Record

- USGS Gages - 1939
- USGS Gages - 1949
- USGS Gages - 1959
- USGS Gages - 1969
- USGS Gages - 1979
- USGS Gages - 1989
- USGS Gages - 1999
- USGS Gages - 2009
- Rivers
- NRD Boundary
- State Boundary



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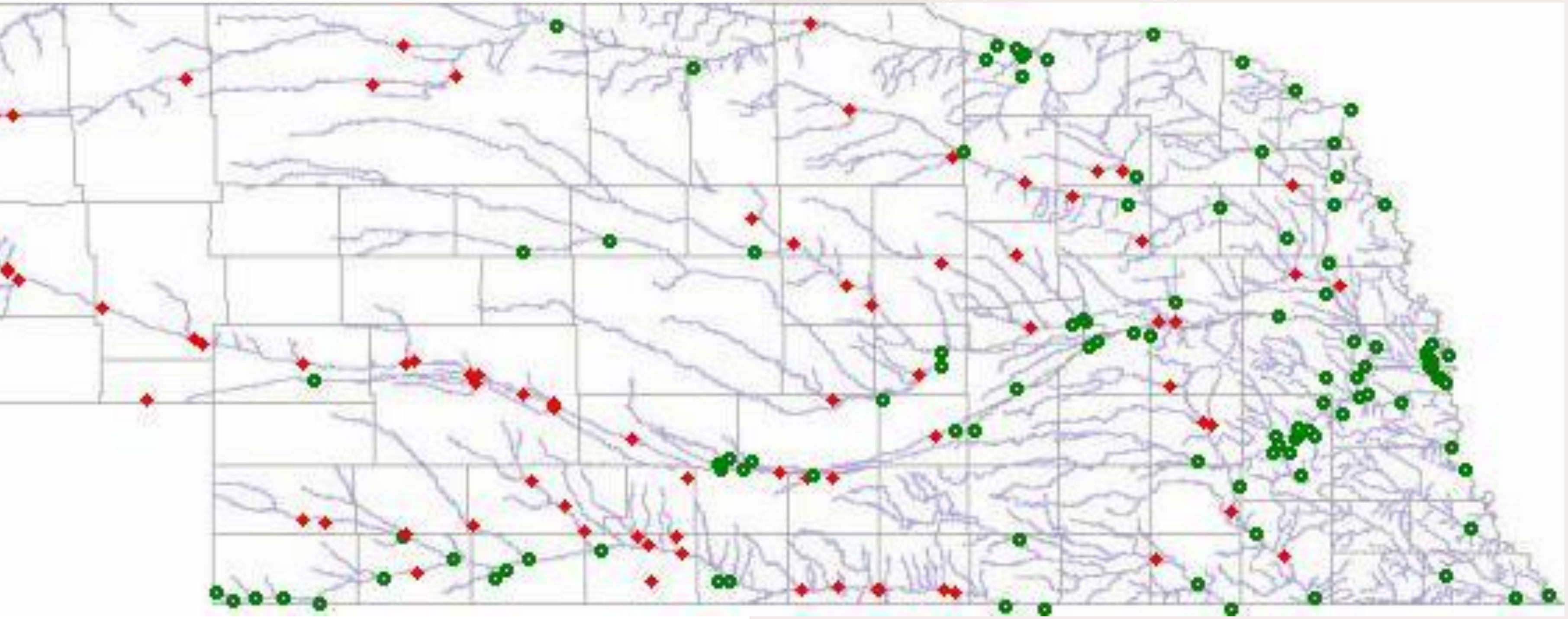
Other Available Gauges

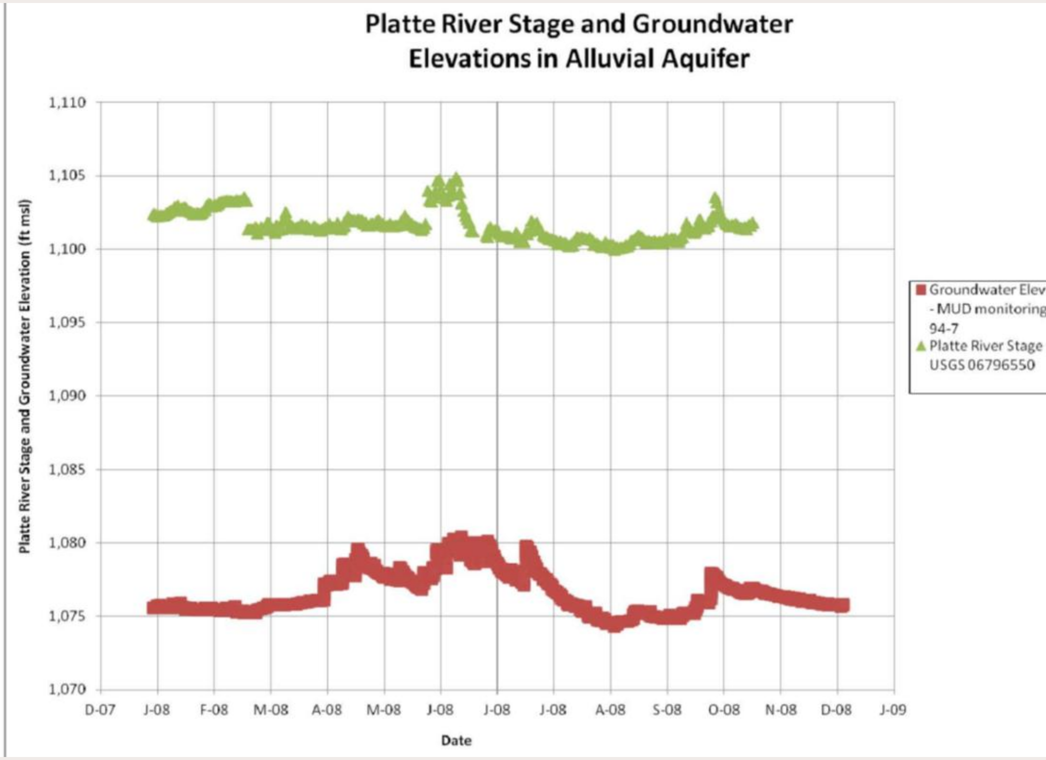


NDNR Stream Gage

USGS Stream Gage

Surface Water/Groundwater Interaction Sites

- Sites where a transducer equipped well and a streamflow gauge are in close proximity
  - Little Nemaha River near Auburn
  - Platte River near Venice



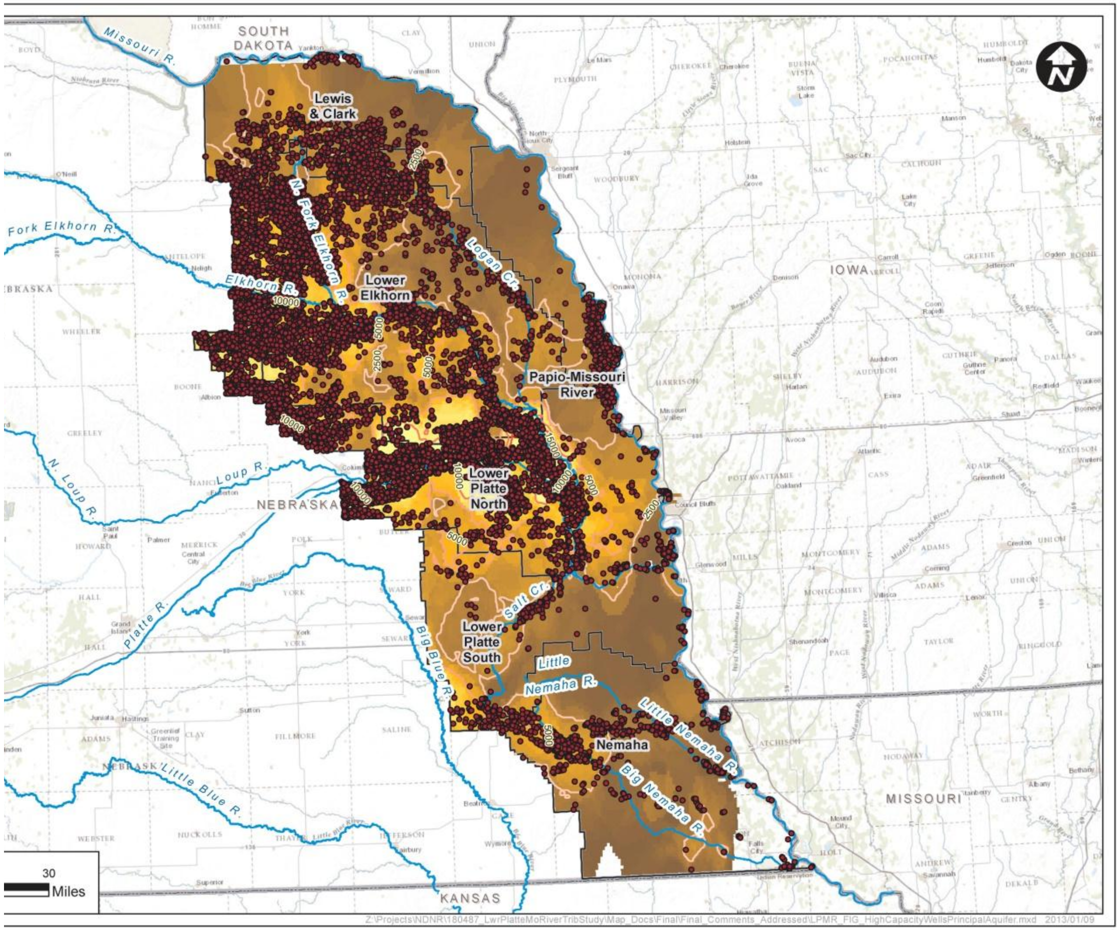
Suggested Approaches to Development of Groundwater Modeling Tools

Review of Model Purpose

- Tool will be used to represent SW-GW interaction
  - Calculate the GW depletion factor in the new Basin Water Supply OA/FA analysis.
    - Illustrate historic usage impacts on current water supplies (both SW and GW)
  - An aid to quantify the Basin Water supply amount of stream/GW depletion
- *Tool should determine the effect (if any) of large-volume well pumping on the baseflow of the rivers and streams within the Study Area.*
  - Tool will be used to calculate transient changes in GW depletion factor

Inferences from the Aquifer Transmissivity Map and the Distribution of High Capacity Wells

- A large portion of the study area consists of low permeability materials with limited high capacity well development
- Most high capacity wells are located in areas where the transmissivity is high



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Low Transmissivity Areas

- There are very few high capacity wells constructed in area where the aquifer transmissivity is low.
- Streamflow depletion due to pumping in these areas should be limited
  - Few wells to impact streamflow
- Future well development in these areas is unlikely, as low permeability materials do not typically sustain high capacity wells
- Limited number of streamflow measurements
- *Development of sophisticated modeling tools in areas where the aquifer transmissivity is low will provide little benefit in the evaluation of stream depletion*

High Transmissivity Areas

- Areas include large parts of:
  - Lower Elkhorn
  - Lower Platte North
- Paleovalleys in:
  - Lewis and Clark
  - Nemaha
- Missouri River alluvium
- Potential increase in future well development in these areas
- Streamflow targets are available
- *Development of a more sophisticated modeling tool could provide a benefit in the evaluation of stream depletion compared to the current analytical tools*

Groundwater Tools and Potential Benefit

- Uses for groundwater tools
  - Develop a water balance within the basin
  - Determine the effect of large-volume well pumping on the stream baseflow
- Development of groundwater modeling tools should be prioritized based on potential benefit to the OA/FA process.
  - Priority should be established based on:
    - Potential for stream/aquifer interconnection – High transmissivity areas
    - Potential impact to streamflow - Number of high capacity wells
    - Availability of other modeling studies that can be used as resources
    - Availability of streamflow targets

Qualitative Cost Benefit Evaluation for Development of Modeling Tools

Region	Number of high capacity wells within this region? Range (Low, or High)	To what degree will a more sophisticated model improve the annual analysis performed by DNR. Range: (Limited Improvement, Somewhat Improve, Significantly Improve)	Are existing models available to help in construction of a new comprehensive model?	Availability of Streamflow Targets Range (Low, Mid, or High)	Estimated Level of Effort Required to Develop a Model Range (Low, Mid, or High)	Cost Benefit Summary
Low Transmissivity Areas	Low	Limited to Somewhat Improve	No large area models are available.	Low	High	High Cost with limited improvement on existing methods.
High Transmissivity Areas	High	Somewhat to Significantly Improve	Several large area models are available: ELM CENEB Platte River Valley - Farm Process Salt Creek	Mid	Mid to High	Mid to high cost with potential for significant. Improvement on existing methods.

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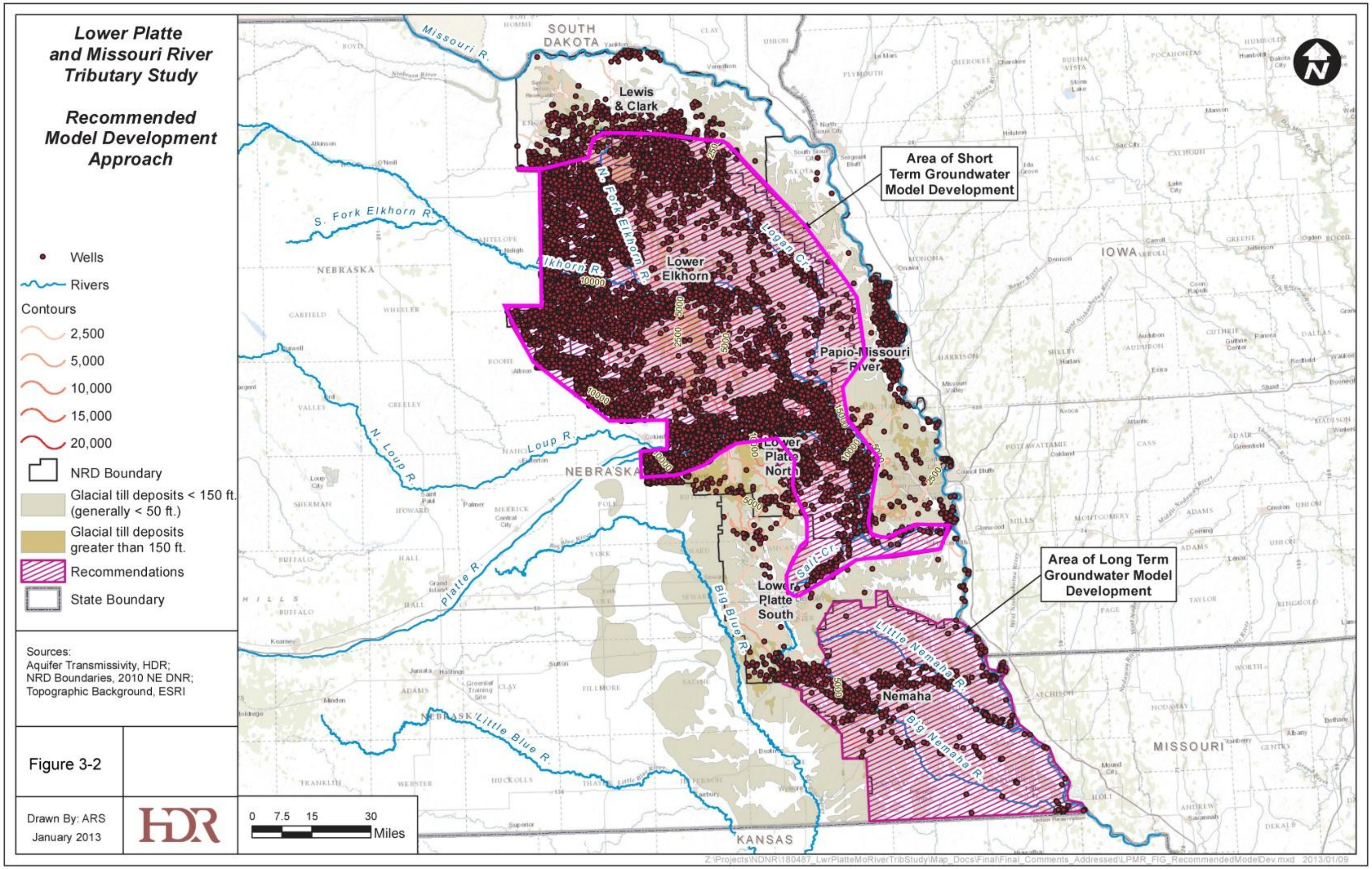
Recommended Areas for Numerical Groundwater Model Development

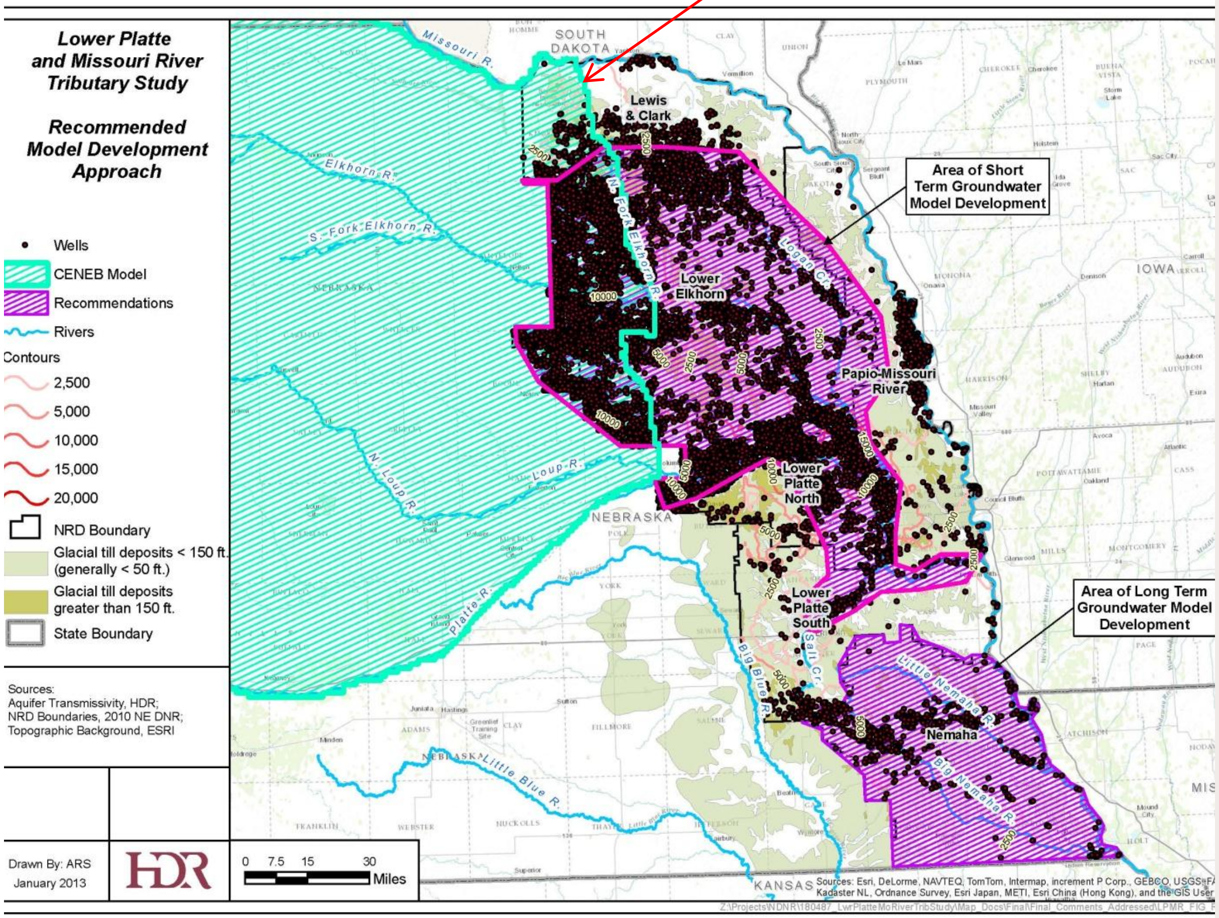


Potential Model Development Approach

Approximate Eastern Extent of ELM and CENEB Models

First Priority Model

- Option 1: Construction of a new model to include the model domain described above
- Option 2: Extend the Elkhorn Loup model or the CENEB model to the east
- Include the Dakota

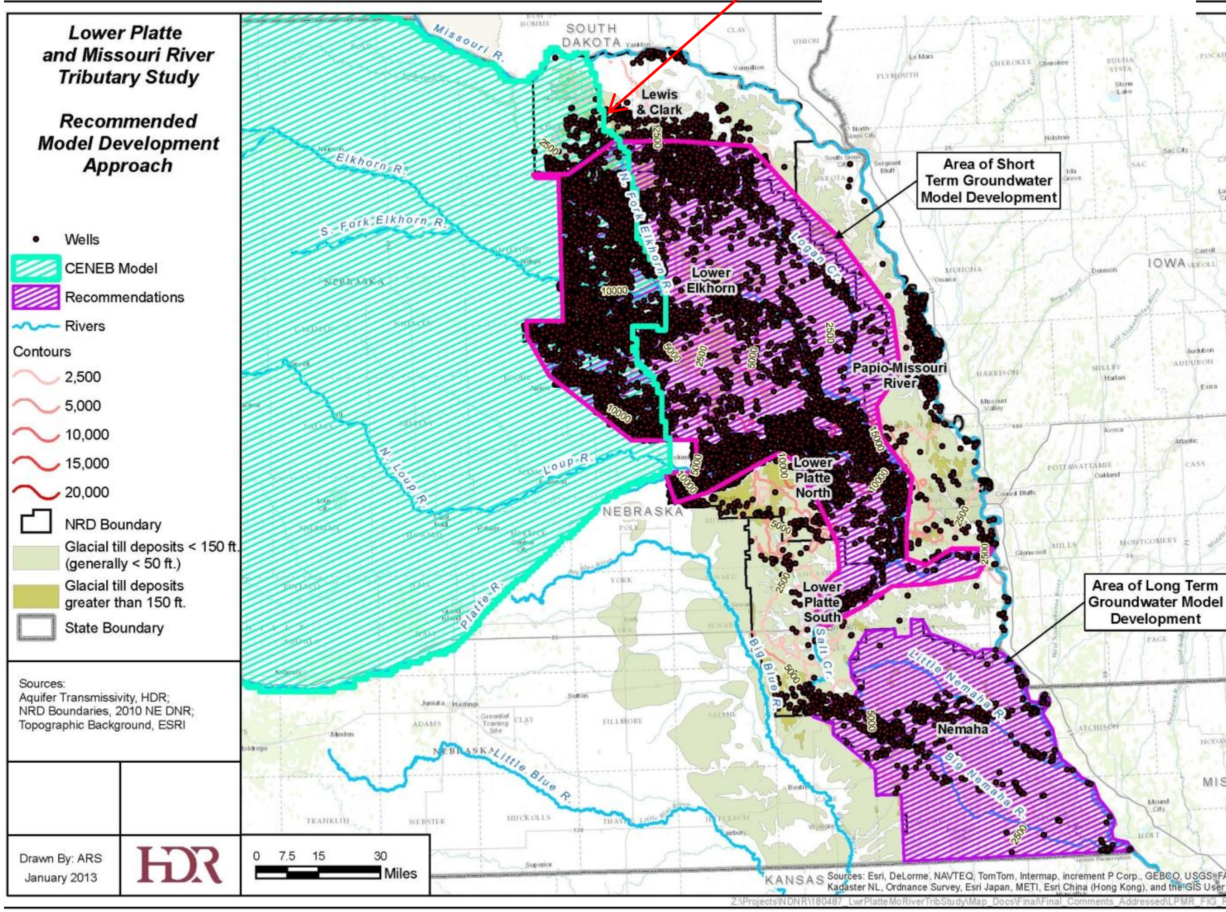


Potential Model Development Approach

Second Priority Model

- Construct a model approximately the size of the Nemaha NRD
- Do not include the Dakota (absent)

Approximate Eastern Extent of ELM and CENEB Models



What to do in Areas Outside of the Proposed Numerical Model Boundary

- Quantify streamflow depletion due to pumping by implementing analytical techniques
  - Maintain approach used in other basins
    - Jenkins
    - Hunt
- Limit the analysis to wells constructed in:
  - The valley deposits of perennial streams
    - Perennial streams defined using the USGS National Hydrography Dataset.
      - Include the main stems of each river and their perennial tributaries
      - Extent of valley deposits can be defined using flood plain maps
    - Defined/mapped paleovalleys

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Summary

- Sufficient data exists to develop groundwater tools, including models, for use in the DNR OA/FA calculation
- The purpose of these tools is to develop a water balance within the basin and determine the effect of large-volume well pumping on the stream baseflow
- A groundwater model that includes much of the Lower Elkhorn and Lower Platte North NRDs could be constructed to evaluate streamflow depletion due to pumping
  - Much of the area has a high aquifer transmissivity, indicating potential for interconnection
  - The proposed model area has a high density of high capacity wells
  - Several modeling studies are available as references
  - Numerous streamflow targets are available
- A separate model could be constructed to evaluate much of the area within the Nemaha
  - Area is unique because of the absence of the Dakota
- In areas of low aquifer transmissivity, analytical techniques could be used

Questions/Discussion